Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 150 (2016) 1192 – 1199

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2016

The Control System Improvement of the City Motor Transportation

I.I. Lyubimov[a,]*, A.N. Melnikov[a], N.A. Trubin[a]

[a] *The Orenburg State University, Victory Avenue 13, 460018 Orenburg, Russia*

Abstract

The authors of the article examine the functions and the development directions of the city motor passenger and specialized transportation system. These two systems are similar in many aspects, but alongside with similarities there are differences which are obviously shown in the regional centers. The main objective of the research is the efficiency increasing of the systems functioning for the adaptive control of the motor transport. The control systems of passenger, cargo, mixed and specialized transportation are considered. The interrelation of the control systems optimization criteria is established according to different types of a transported freight.

Peer-review under responsibility of the organizing committee of ICIE 2016

Keywords: control of motor transportation; collection and removal of solid domestic wastes; structure of fleet.

1. Introduction

The development of the economic relations is connected with the growth of the competition in the motor transportation market. It also affects municipal freight and passenger service. On the one hand, there is a customer – municipality – which forms the requirements to transportation: the volumes of transport work, traffic intervals and other parameters at the fixed and, as a rule, defined budget. On the other hand there are consumers of transport services, in the person of residents and the enterprises of different forms of ownership.

Thus there is the necessity of the organization, coordinating, management and control of transport work performance.

* Corresponding author. Tel.: +7-903-367-7770; fax: +7-353-291-2226.
E-mail address: lyubimovii@gmail.com

Peer-review under responsibility of the organizing committee of ICIE 2016
doi:10.1016/j.proeng.2016.07.235

2. Description of the system

The most effective method of ensuring control is supervisory control. The task of such system is to increase the effectiveness of traffic control, the road network capacity, to prevent automobile jams, to reduce the traffic delays, to increase traffic safety, to inform traffic participants about the road and transport situation and variants of an optimum traffic route, to ensure the uninterrupted traffic of land city passenger transport.

The functions of the supervisory control system of motor transportation are:

The control – to obtain information on current state of a control object for the assessment of the aims achievement and the subsequent regulation (supervision over the traffic regularity of buses on a route);

The regulation – to correct of the actual status of a control object according to the found deviation from a desirable status (replacement of the faulty bus by the reserve);

The organization – to establish the initial status of a control subject (the formation of the organizational control structure);

The coordination – to coordinate the interests of various components of the control system which have the independent purposes and interests (coordination of interests between the organizations of bus and city electric transport for the common operation of terminal route station);

The activity accountancy and analysis – to systematize the data obtained at controlling and to establish the regularities and the reasons of deviations from the planned purposes and status of a control object (maintaining the registration documentation and the analysis of the production economic activity);

The prediction – to establish the expected status of a control object (the definition of the expected implementation of the plan concerning revenue collecting);

The management – administrative actions for transferring the execution instructions by heads to the subordinates;

Targeting – to establish the objectives of control and desirable status of a control object (the achievement of the certain traffic regularity for buses);

Planning – to develop the impact programs on a control object and the definition of necessary resource providing (scheduling of route system development for a year) [1-6, 9-11, 13-22, 29-51, 53, 54, 56-59].

The supervisory centers exist almost in all cities of the Russian Federation. Such central transport supervisory service (CTSS) was also organized in Orenburg based on the enterprise “Orenburg Passenger Transportation”.

The functional scheme of Orenburg CTSS is presented in figure 1.

One of the suggested directions in the development of CTSS is the use of the service opportunities for the organization and management of collection and removal of solid domestic wastes (SDW) because normal functioning of the settlement namely the sanitary and hygienic situation, the ecological situation, the social and economic situation, esthetics of the settlement depend on timely waste collection and removal.

The volume of SDW formation depends on a number of factors (population density, seasonality, etc.). In the conditions of constantly changing demand for SDW collection and removal there is a problem of operating modes adaptation for rolling stock to the external changing conditions which are characterized by the intensity of wastes formation, environment temperature, SDW properties (the decomposition period, etc.).

The variation of SDW transportation volumes predetermines the use of the corresponding ways of the route and logistic scheme organization for SDW removal providing social needs of the settlement, sanitary and epidemiologic and ecological indicators for the prescribed service conditions.

Nowadays the problems solution for the logistic scheme optimization of solid domestic wastes collection and removal from the settlement territory can be successfully realized only on the basis of the use of modern high-tech information technologies based on domestic and foreign scientists’ achievements. The existing methods don't possess the sufficient flexibility in relation to the external changing conditions [7, 8, 12, 23-28, 52, 55].

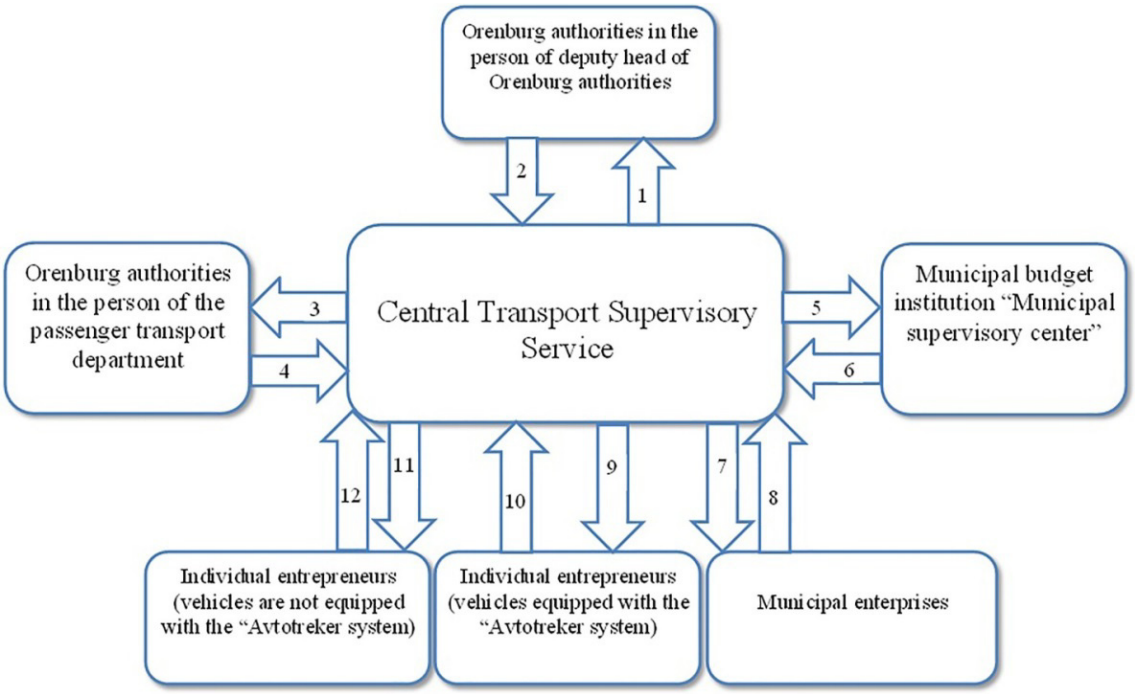

Fig. 1. Functional scheme of "Central Transport Supervisory Service" in Orenburg. (1, 3) the report for 24 hours on the traffic regularity of passenger transport; (2) operational instructions on the traffic organization of passenger transport; (4) information: about the enterprises which are the competition winner on the right of the implementation of passenger transportation on municipal routes in Orenburg; (5, 12) information on the actual quantity of rolling stock on municipal routes, information on the current roads functioning; (6) information on emergency situations in Orenburg; (7, 9, 11) information on the actual quantity of rolling stock on each route, being served by this enterprise; (8, 10) information on functioning status of navigation modules on vehicles

Thus the implementation problem of new methods and also the development of the existing methods for the logistic scheme formation of the control system improvement at collecting and removing of solid domestic wastes from the settlement territory is actual.

3. Formation of mathematical models of the transport operation control

The management on loading capacity is used at the heart of the mathematical model formation for the transport work management of specialized rolling stock at SDW collecting and removing.

Loading capacity utilization ration $Y(t)$:

$$Y(t) = \frac{M(t)}{G}., \tag{1}$$

where M – mass of loading, t;

G – loading capacity of vehicle , t.

Loading mass:

, (2)

where – number of containers, units;

– medium mass of SDW in a container.

Number of containers:

$$N_C = \frac{L_m}{L_{med}} \cdot n_{med}^{pl}, \quad (3)$$

where – route length, km.;
– medium distance between loading points (container platform), km.;
– medium quality of containers on the platform, units.

SDW mass in one container:

$$m_c^{med} = V_C \cdot \rho_{SDW} \cdot Y_C(t), \quad (4)$$

where – container volume, m^3;
– medium density of SDW , kg/m;
– coefficient of container fullness.

The criterion function of the efficiency optimization for loading capacity can be presented in the following form:

$$Y(t) = \frac{L_m \cdot V_C \cdot \rho_{SDW} \cdot Y_C(t) \cdot m_c^{med}}{L_{med} \cdot G} \to \max, \quad (5)$$

assuming that load weight is less than loading capacity of the vehicle .

The practical implementation of the theoretical fundamentals is possible on the basis of the use of the built-in means for load measuring on the vehicle - load sensors on an axis or pressure sensors.

Load sensors on axes are intended for load control on axes and load weight as a part of motor transport monitoring systems.

The pressure sensor is used on the vehicles equipped with pneumosuspension. The sensor can be installed instead of blanking cover in the system of pneumosuspension.

The sensor of angular movement is installed between the load platform (or a frame) and the sprung axis by means of the levers system for the vehicles with a leaf-spring suspension.

The offered control system is intended for remote monitoring of vehicles, mobile objects and valuable loads in real time. The use of the GLONASS/GPS complexes and cellular communication is at the heart of the complex. The complex functionally consists of hardware and program parts. The scheme of the control system of the city motor transportation is presented in a general view in figure 2.

The information from the external sensors connected to special analog and digital entrances of the terminal is added to the obtained navigation data, so all cumulative information sending is transferred on communication channels to the server of the monitoring system, and from the server - to the control center. The data exchange with the onboard terminal is carried out on GSM channels.

The algorithm of transportation control on the basis of the onboard system use of loading capacity control is presented in figure 3.

The scheme shows the operation of garbage trucks before and after the implementation of the monitoring system of loading capacity. Before the system implementation the SDW unloading was carried out after each run, so the work on a route was carried out without controlling of loading degree.

After the implementation of the onboard monitoring system of loading capacity, there is an opportunity to estimate loading degree after each run, that is before the garbage truck goes to the following run there is an assessment of loading degree and the choice is carried out either to go to unloading or to the following run.

The results of the development of the control system of the city motor transportation allow to operate the transport work of rolling stock on the basis of the control of its loading capacity and passenger capacity use.

The existing technical means allow to realize the control algorithm on the basis of the GLONASS-GPS and GSM technologies.

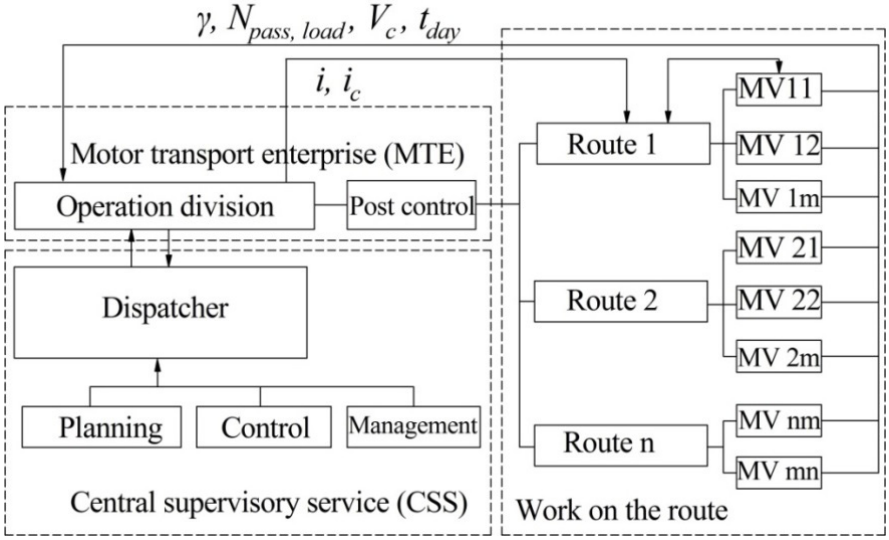

Fig. 2. The scheme of the control system of the city motor transportation. (MV) - motor vehicle

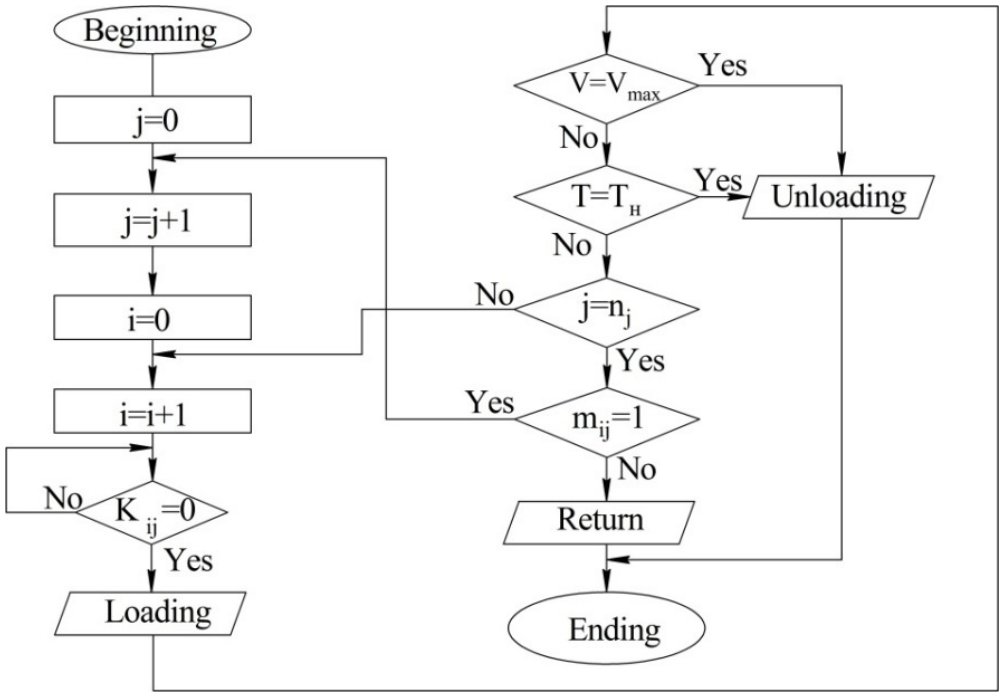

Fig. 3. The algorithm of transportation control on the basis of the loading capacity control system. j – route number; i – number of a container platform; K_i – parameter of the container platform fullness; K_j=0, if the containers are unloaded; K_j=1, if the containers are loaded; V – volume of the body loading; V_{max} – maximum volume; T – work time on the route; n_j – number of platforms on j-route; m_j – parameter of undischarged containers on j-route; m=1, if there are undischarged containers; m=0, if there are no undischarged containers

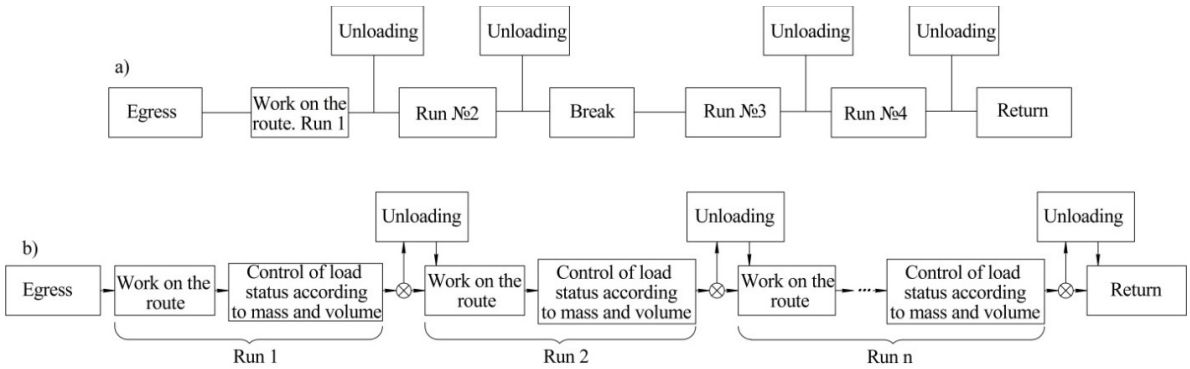

Fig. 4. The scheme of the transportation organization before and after the implementation of the system of the adaptive management. (a) before – *L=const*, (b) after – *L=const; G=const; V=const*

4. Conclusions

According to the results of the researches it is possible to draw the following conclusions.

There is a problem of the control of the city transportation consisting in receiving timely and reliable information about the status of the transportation objects and vehicles work on a route when performing transport processes.

The realization of collecting and removing of solid domestic wastes from the territory of the settlement is carried out according to the fixed routes that is connected with the underexploitation of vehicles loading capacity.

The suggested mathematical model and control algorithm allow the central supervisory service to operate the vehicles work when collecting and removing solid domestic wastes on the basis of the information about the vehicle loading and location owing to the operational correcting of the traffic route.

References

[1] K. Aboudolas, M. Papageorgiou, E.B. Kosmatopoulas, Store-and-forward based methods for the signal control problem in large scale urban road networks, Transportation Research Part C. 17 (2009) 163–174.

[2] R.E. Allsop, Some possibilities for using Traffic Control to Influence Trip Distribution and Route Choice, in: Proceedings of the Sixth International Symposium on Transportation and Traffic Theory, Sydney. (1974) 345–374.

[3] G. Bellei, G. Gentile, N. Papola, A within-day dynamic traffic assignment model for urban road networks, Transportation Research Part B. 39 (2005) 1–29.

[4] R.W. Bentley, T.A. Lambe, Assignment of traffic to a network of signalized city streets, Transportation Research Part A. 14 (1980) 57–65.

[5] J. Bie, H.K. Lo, Stability and attraction domains of traffic equilibria in a day-to-day dynamical system formulation, Transportation Research Part B. 44 (2010) 90–107.

[6] M.C. Bliemer, L. Brederode, L. Wismans, E. Smits, Quasi-dynamic network loading: adding queuing and spillback to static traffic assignment, in: Proceeding of Transportation Research Board 91st Annual Meeting TRB. (2012) 29–56.

[7] E.V. Bondarenko, A.A. Goncharov, S.E. Gorlatov, K.I. Manaev, A.N. Melnikov, N.A. Trubin, Concept of municipal road transport, The world of transport and technological machines. 2 (2015) 110–116.

[8] Ye.V. Bondarenko, A.O. Zuyev, I.I. Lyubimov, K.I. Manayev, A.N. Mel'nikov, Infrastructure optimization of collection and removal of solid domestic wastes from the settlement territory, Vestnik of the Moscow automobile and road construction state technical university (MADI). 4 (2011) 92–96.

[9] E. Cascetta, A stochastic process approach to the analysis of temporal dynamics in transportation networks, Transportation Research Part B. 23 (1989) 1–17.

[10] E. Cascetta, M. Gallo, R. Montella, Models and algorithms for the optimization of signal settings in urban networks with stochastic assignment models, Annals of Operations Research. 144 (2006) 301–328.

[11] T.J. Dickson, A note on traffic assignment and signal timings in a signal-controlled road network, Transportation Research Part B. 15 (1981), 267–271.

[12] A.P. Fot, N.N. Yakunin, D.A. Dryuchin, V.A. Pogorelov, A.V. Artamkin, S.N. Yakunin, Improving the efficiency of the vehicle fleet operating at the expense of optimization of its structure, Vestnik of OSU. 2 (2007) 158–163.

[13] N.H. Gartner, Area Traffic Control and Network Equilibrium, Traffic Equilibrium Methods, Lecture Notes in Economics and Mathematical Systems. 118 (1976) 274–297.
[14] N.N. Gartner, J.D. Little, H. Gabay, Optimisation of traffic signals by mixed integer programming, Part 1: The network coordination problem, Transportation Science. 9 (1975) 321–343.
[15] J. Gregoire, E. Frazzoli, T. Wongpiromsarn, Back-pressure traffic signal control with unknown routing rates, arXiv: 1401.3357v2 [cs.SY]. (2014).
[16] X. He, X. Guo, H. Liu, A link-based day to day traffic assignment model, Transportation Research Part B. 44 (2010) 597–608.
[17] B.G. Heydecker, Objectives, stimulus and feedback in signal control of road traffic, ITS Journal. 8 (2004) 63–76.
[18] T. Hu, H.S. Mahmassani, Day to day evolution of network flows under real-time information and reactive signal control, Transportation Research C. 5 (1997) 51–69.
[19] T.Le, P. Kovacs, N. Walton, H.L. Vu, L.H. Andrew, S.P. Hoogendoorn, Decentralised Signal Control for Urban Road Networks, arXiv: 1310.0491v2 [math.OC]. (2014).
[20] R. Liu, Traffic Simulation with DRACULA, Fundamentals of Traffic Simulation, Springer, 2010.
[21] R. Liu, M.J. Smith, Route choice and signal control: a study of the stability and instability of traffic signal controlled networks, Transportation Research Part B. 77 (2015) 123–145.
[22] R. Liu, D. Watling, Microsimulation models incorporating both demand and supply dynamics, Transportation Research. 40A (2006) 125–150.
[23] I.I. Lyubimov, Indicators demand for urban passenger transport (by the example of Orenburg), Bulletin of the Orenburg State University. 115 (2009) 139–143.
[24] L.I. Lyubimov, K.I. Manayev, A.N. Mel'nikov, V.I. Rassokha, The algorithm development for the optimization of the rolling stock and container park at collecting and removing solid domestic wastes, Proceedings of the Tula state university, Technical sciences. 4 (2011) 174–182.
[25] I.I. Lyubimov, K.I. Manayev, A.N. Mel'nikov, N.Z. Sultano, Methodical fundamentals of the process optimization for collecting and removing solid domestic wastes, Intellect: Innovations, Investments. 2 (2011) 35–40.
[26] I.I. Lyubimov, N.Z. Sultanov, Ye.V. Bondarenko, To the subject of the rational structure formation of the city passenger transport in Orenburg, Vestnik of the Moscow automobile and road construction state technical university (MADI). 3 (2009) 21–25.
[27] I.I. Lyubimov, N.Z. Sultanov, Theoretical bases of perfection transport system, Bulletin of the Orenburg State University. 10 (2014) 121–123.
[28] I.I. Lyubimov, K.I. Manayev, A.N. Mel'nikov, N.Z. Sultanov, Specific function formation for the transport and logistic scheme optimization at collecting and removing of solid domestic wastes, Intellect: Innovations, Investments. 3 (2011) 5–8.
[29] M.J. Maher, X. Zhang, A Bi-level Programming approach for Trip Matrix Estimation and Traffic Control Problems with Stochastic User Equilibrium Link Flows, Transportation Research Part B. 35 (2001) 23–40.
[30] M. Maher, R. Liu, D. Ngoduy, Signal optimisation using the cross entropy method, Transportation Research Part C. 27 (2013) 76–88.
[31] C. Meneguzzer, Review of models combining traffic assignment and signal control, Journal of Transportation Engineering. 123 (1997) 148–155.
[32] R. Mounce, M.J. Smith, Uniqueness of equilibrium in steady state and dynamic traffic networks, Transportation and Traffic Theory. 2007 (281–299).
[33] R. Mounce, Convergence in a continuous dynamic queueing model for traffic networks, Transportation Research Part B. 40 (2006) 779–791.
[34] R. Mounce, Existence of equilibrium in a continuous dynamic queueing model for traffic networks with responsive signal control, in: Proceeding Of the 18th International Symposium on Transportation and Traffic Theory. (2009) 327–344.
[35] R. Mounce, M. Carey, Route swapping in dynamic traffic networks, Transportation Research Part B. 45 (2011) 102–111.
[36] Y. Nesterov, Stationary dynamic solutions in congested transportation networks, Networks and Spatial Economics. 3 (2003) 371–395.
[37] Y. Nie, A class of bush-based algorithms for the traffic assignment problem, Transportation Research Part B. 44 (2010) 73–89.
[38] Traffic Engineering and Control, Proceedings of the Symposium on Traffic Control Systems. 21 (1980) 298–302.
[39] S. Smale, Exchange Processes with Price Adjustment, Math. Econ. 3 (1976) 211–226.
[40] M. Smith, A local traffic control policy which automatically maximises the overall travel capacity of an urban road network, 1979.
[41] M. Smith, Traffic control and route-choice; a simple example, Transportation Research. 13B (1979) 289–294.
[42] M.J. Smith, A descent algorithm for solving a variety of monotone equilibrium problems, in: Proceedings of the Ninth International Symposium on Transportation and Traffic Theory. (1984) 273–297.
[43] M.J. Smith, Traffic control and traffic assignment in a signal-controlled network with queueing, in: Proceedings of the 10th International Symposium on Transportation and Traffic Theory. (1987) 61–68.
[44] M.J. Smith, Intelligent Network Control: Using an Assignment-Control Model to Design Fixed Time Signal Timings, New Developments in Transport Planning – Advances in Dynamic Traffic Assignment. (2010) 57–72.
[45] M.J. Smith, Traffic signal control and route choice: A new assignment and control model which designs signal timings, Transportation Research Part C. (2015).
[46] M.J. Smith, M.O. Ghali, The dynamics of traffic assignment and traffic control; a theoretical study, Transpn. Res. Part B. 24 (1990) 409–422.
[47] M.J. Smith, R. Mounce, A splitting rate model of traffic re-routeing and traffic control, Transportation Research Part B. (2011) 1389–1409.
[48] M.J. Smith, Traffic equilibrium with responsive traffic control, Transportation Science. 27 (1993) 118–132.
[49] M.J. Smith, B.G. Heydecker, The interaction between signal control policies and route choice, in: Proceedings of the Tenth International Symposium on Transportation and Traffic Theory. (1987) 319–338.
[50] M.J. Smith, The existence, uniqueness and stability of traffic equilibria, Transportation Research Part B. 13 (1979) 295–304.

[51] M.J. Smith, Dynamics of route choice and signal control in capacitated networks, Journal of Choice Modelling. 4 (2011) 30–51.
[52] N.Z. Sultanov, I.I. Lyubimov, Choice of rational structure of rolling stock road transport companies, Multidisciplinary network electronic scientific journal of the Kuban State Agrarian Universit. 26 (2007) 127–143.
[53] H. Taale, The combined traffic assignment and control problem – an overview of 25 years of research, in: Proceedings of the 9th World Conference on Transport Research (WCTR), Seoul, Korea. (2001) 22–27.
[54] T. Tassiulas, A. Ephremides, Stability properties of constrained queueing systems and scheduling policies for maximum throughput in multihop radio networks, IEEE Transactions on Automatic Control. 37 (1992) 1936–1948.
[55] N.V. Vagapova, B.A. Portnikov, N.Z. Sultanov, I.I. Lyubimov, Functional processes management of city passenger transportation, Intellect: Innovations, Investments. 2 (2009) 49–56.
[56] P. Varaiya, Max pressure control of a network of signalised intersections, Transportation Research Part C. (2013) 177–195.
[57] J.G. Wardrop, Some theoretical aspects of road traffic research, Proceedings of the Institute of Civil Engineers Part 2. 1 (1952) 325–378.
[58] F.V. Webster, Traffic Signal Settings, Department of Transport, Road Research Technical Paper. 39 (1958).
[59] H. Yang, S. Yagar, Traffic assignment and signal control in saturated road networks, Transportation Research Part A. 29 (1995) 125–139.